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FOREIGN TECHNOLOGY DIV WRIGHT-PATTERSON AFB OH  
SOVIET MATHEMATICAL PROGRAMMING. (U)  
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### COMMENTS ON SURVEY

- o BASED ENTIRELY ON REVIEW OF SOVIET TEXTS AND JOURNALS
- o SEVERAL REFERENCES HAVE DIRECT MILITARY APPLICATION
- o MILITARY APPLICATIONS ARE NOT NECESSARILY ACTUAL
- o MANY REFERENCES TO THEORETICAL DEVELOPMENTS AND NON-MILITARY APPLICATION
- o ALL CONCLUSIONS SUBJECT TO UNCERTAINTY

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CONTENTS:

- PROBLEM DEFINITIONS
- MILITARY APPLICATIONS
- MILITARY ADVOCACY
- BRIEF CHRONOLOGY
- SELECTED SPECIALISTS
- IMPLICATIONS AND FUTURE

PROBLEM

DEFINITIONS

MATHEMATICAL PROGRAMMING:

OPTIMIZING SUBJECT TO RESOURCE CONSTRAINTS  
(CONSTRAINED OPTIMIZATION)

UNCONSTRAINED OPTIMIZATION:

MAXIMIZING OR MINIMIZING SUBJECT TO NO  
CONSTRAINTS

## MATHEMATICAL PROGRAMMING (MP) MODEL

MAXIMIZE OR MINIMIZE:  $F(x_1, x_2, \dots, x_N)$

SUBJECT TO:  $G_1(x_1, x_2, \dots, x_N) \leq 0$

....

$G_M(x_1, x_2, \dots, x_N) \leq 0$

$H_1(x_1, x_2, \dots, x_N) = 0$

....

$H_K(x_1, x_2, \dots, x_N) = 0$

LINEAR PROGRAMMING

- ALL FUNCTIONS ARE LINEAR

NONLINEAR PROGRAMMING

- AT LEAST ONE FUNCTION IS NONLINEAR

## MATHEMATICAL PROGRAMMING TYPES

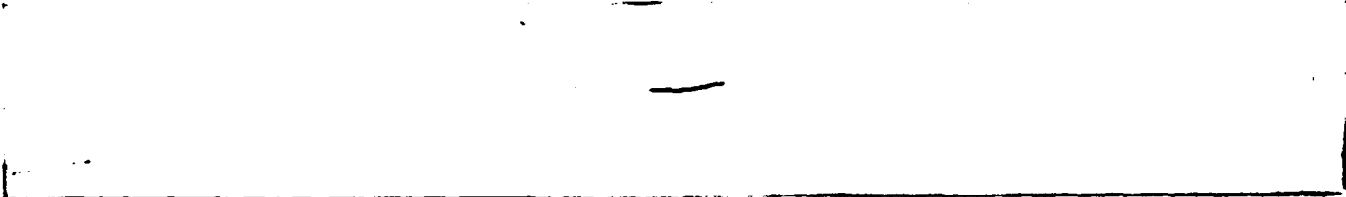
- o LINEAR PROGRAMMING (LP)
- o INTEGER PROGRAMMING (IP)
- o DYNAMIC PROGRAMMING (DP)
- o NONLINEAR PROGRAMMING (NLP)
- o QUADRATIC PROGRAMMING (QP)
- o CONVEX PROGRAMMING (CP)
- o STOCHASTIC PROGRAMMING (SP)
- o MULTI-CRITERIA PROGRAMMING (MCP)





MILITARY

APPLICATIONS



SOME SOVIET MILITARY APPLICATIONS OF MATHEMATICAL  
PROGRAMMING

o WEAPON/TARGET ASSIGNMENT PROBLEM

- MAXIMIZE TARGETS DESTROYED
- MINIMIZE WEAPONS USED
- MINIMIZE TIME
- MINIMIZE LOSS OF FRIENDLY TROOPS

o FORCE OR SUPPORT TRANSPORTATION/DEPLOYMENT

- MINIMIZE MOVEMENT COST
- MINIMIZE DISTANCE TRAVELED
- MAXIMIZE AIRCRAFT LOAD
- MINIMIZE FUEL
- MINIMIZE DEPLOYMENT TIME

o ARMAMENT DESIGN AND PRODUCTION

- MINIMIZE COST
- MAXIMIZE EFFECTIVENESS
- MAXIMIZE RELIABILITY

SOME SOVIET MILITARY APPLICATIONS OF MATHEMATICAL  
PROGRAMMING (CONTD)

o ARMAMENT EMPLOYMENT

- MAXIMIZE SYSTEM RELIABILITY
- MAXIMIZE PROBABILITY OF MISSION COMPLETION
- MAXIMIZE RECONNAISSANCE EFFECTIVENESS
- MINIMIZE DEFENSE EFFECTIVENESS

MILITARY

ADVOCACY

## OPTIMIZATION

- o "IN SELECTING OPTIMUM PARAMETERS OF ARMAMENT AND THE METHODS FOR ITS UTILIZATION, WE HAVE TO DETERMINE THE OPTIMUM VALUES FOR THE VARIOUS CRITERIA OF EVALUATING THE ARMAMENT AND THE EFFECTIVENESS OF ITS COMBAT APPLICATION".

- YU. V. CHUYEV (1965; P. 256)

- o "THE QUESTION OF DETERMINING THE OPTIMAL SIZE OF DEFENSE RESOURCES IS THE CENTRAL QUESTION OF A MILITARY-ECONOMIC ANALYSIS".

- K. V. TARAKANOV (1974; P. 39)

## OPTIMIZATION

ON THE SUBJECT OF: ARMY COMMAND STAFF TACTICAL EXERCISES

- o "THE IMPORTANT VALUE DURING (TACTICAL) CONCEPT DEVELOPMENT IS THE DETERMINATION OF COMBAT SCENARIOS FOR THE RESEARCH OF BASIC QUESTIONS AND FORMATION OF THEIR FINAL IMPROVEMENT. A QUANTITY OF THE MOST IMPORTANT COMBAT SCENARIOS MUST BE STUDIED IN ORDER TO SELECT THE OPTIMUM."

- I. SHAVROV (1977, P. 68)

- o "THE BASIS OF RESEARCH FOR THIS TYPE OF PROBLEM IN MANY INSTANCES UTILIZES LOGIC-MATHEMATICAL MODELS AND COMPUTER TECHNOLOGY TO ASSIST THE EXPERIENCED AND MOST PREPARED OFFICERS."

- I. SHAVROV (1977, P. 65)

## LINEAR PROGRAMMING

- o "AT THE PRESENT TIME, THIS METHOD HAS RECEIVED WIDESPREAD USE IN SOLVING MANY MILITARY PROBLEMS"

- I. ANUREYEV (1967, P. 93)

- o "SOLUTION OF PROBLEMS UNDER CONDITIONS OF INCOMPLETE INFORMATION, WHICH IS PARTICULARLY CHARACTERISTIC OF COMBAT SITUATIONS...ARE RESPONSIBLE FOR THE EXTENSIVE USE OF THE METHODS OF LINEAR PROGRAMMING IN THE SOLUTION OF MILITARY PROBLEMS"

- YU. V. CHUYEV (1965; P. 262)

- o "LINEAR PROGRAMMING AND GAMING THEORY...MAKE POSSIBLE RATIONAL DECISION MAKING AND RATIONAL PLANNING FOR THE USE OF AVAILABLE NUCLEAR WEAPONS..."

- K. V. TARAKANOV (1974; P. 41)

- o "THE CAPABILITIES OF THEORETICAL-GAMING METHODS ALONG WITH LINEAR PROGRAMMING (ARE) THE MOST COMMON METHODS OF TASK RESOLUTION...USED IN PRACTICE"

- K. V. TARAKANOV (1974; P. 101)

## NONLINEAR PROGRAMMING

- 0 "(USED IN) MANY PROBLEMS, IN PLANNING THE APPLICATION OF WEAPONS, FOR INSTANCE WHEN SEVERAL WEAPONS ARE APPLIED TO ONE TARGET"

- I. ANUREYEV (1967, P. 93)

- 0 "OTHER PROBLEMS IN NONLINEAR PROGRAMMING INCLUDE THE PROBLEM OF OPTIMUM TARGET DISTRIBUTION FOR AN ANTI-AIRCRAFT DEFENSE SYSTEM, DEVELOPMENT OF PLANS FOR AERIAL ATTACKS ON OBJECTIVES".

- YU. V. CHUYEV (1965; P. 273)



(M I X E D) I N T E G E R P R O G R A M M I N G

- o "MANY MILITARY PROBLEMS, SUCH AS PROBLEMS OF TARGET DISTRIBUTION OF ANTI-AIRCRAFT DEFENSE WEAPONS, GROUND WEAPONS OF DESTRUCTION AND OTHERS DEMAND THE METHOD OF INTEGER PROGRAMMING"

- I. ANUREYEV (1967, P. 93)

## DYNAMIC PROGRAMMING

- o "IN APPLICATION TO PLANNING MILITARY OPERATIONS, DYNAMIC PROGRAMMING ALLOWS ONE TO MAKE QUANTITATIVE RECOMMENDATIONS FOR DISTRIBUTING FORCES AND WEAPONS BY STAGES OF AN OPERATION"

- I. ANUREYEV (1967, P. 94)

- o "DYNAMIC PROGRAMMING (IS USED) FOR RECEIVING QUANTITATIVE RECOMMENDATIONS FOR DEPLOYMENT OF FORCES AND MEANS BY ASSIGNMENTS (STAGES) OF THE OPERATION WITH A GOAL OF ACHIEVING THE GREATEST EFFECT AT THE END OF AN OPERATION"

- K. V. TARAKANOV (1974, P. 50)

BRIEF  
CHRONOLOGY

1964

#### EARLY SOVIET DEVELOPMENT

- o YE. S. VENTTSEL AUTHORED INTRODUCTION TO OPERATIONS RESEARCH
- o PROBLEMS CONNECTED WITH COMBAT APPLICATION OF TECHNOLOGY
- o TIME IS A KEY FACTOR THEREFORE COMBAT AUTOMATION IS CRITICAL
- o TACTICAL PROBLEMS: SELECTING BEST METHODS OF USING EXISTING WEAPONS
- o TECHNICAL PROBLEMS: SELECTING OPTIMAL CHARACTERISTICS OF FUTURE WEAPONS
- o BASIC PURPOSE IS A QUANTITATIVE BASIS FOR OPTIMAL DECISIONS
- o MP APPLICATIONS: WEAPON ALLOCATION, LOGISTICS, AIRCRAFT MANEUVERS

1965

## EARLY SOVIET DEVELOPMENT

- o MAJOR-GENERAL YU. V. CHUYEV CO-AUTHORED FUNDAMENTALS OF OPERATIONS RESEARCH IN COMBAT MATERIALS AND WEAPONRY
  - FOR ENGINEERS WHO DEVELOP, TEXT, PRODUCE AND OPERATE COMBAT EQUIPMENT
  - FIRST OPERATIONS RESEARCH TEXT BY MILITARY AUTHORS
  - OPTIMIZATION METHODS PRESENTED FOR MILITARY ENGINEERING PROBLEMS
  - VENTTSEL (1964) RECOMMENDED TO READERS
  - OPERATIONS RESEARCH IS USED TO FIND OPTIMUM SOLUTIONS
  - MP APPLICATIONS: WEAPONS SELECTION, FLIGHT PATH OPTIMIZATION

1970

C O N T I N U E D   S O V I E T   P R O G R E S S

- o MAJOR GENERAL YU. V. CHUYEV AUTHORED RESEARCH ON MILITARY OPERATIONS  
PUBLISHED BY MILITARY PUBLISHING HOUSE
- FOR OFFICERS, STAFFS, MILITARY EDUCATION INSTITUTIONS, DEFENSE INDUSTRY
- DEALS WITH TACTICAL PROBLEMS PARTICULARLY TROOP CONTROL
- DISCUSSES USE OF SEARCH TECHNIQUES AND HEURISTIC PROGRAMMING

1971

C O N T I N U E D   S O V I E T   P R O G R E S S

- o MAJOR GENERAL YU. V. CHUYEV AND G. P. SPEKHOVA CO-AUTHORED TECHNICAL PROBLEMS OF OPERATIONS RESEARCH
- FOR RESEARCH INSTITUTE AND DESIGN BUREAU EXECUTIVES, ENGINEERS, STUDENTS OF TECHNICAL SCHOOLS
- DEALS WITH SOLVING DESIGN PROBLEMS ASSOCIATED WITH TECHNICAL DEVICES
- SURVEY OF MATHEMATICAL PROGRAMMING AND COMPARISON OF METHODS PRESENTED
- MP APPLICATIONS: WEAPONS DESIGN (PARAMETER SELECTION AND REPLACEMENT)

1972

CONTINUED SOVIET PROGRESS

- o GENERAL-COLONEL V. V. DRUZHININ AND COLONEL-ENGINEER D. S. KONTOROV  
CO-AUTHOR CONCEPT, ALGORITHM, DECISION IN THE SOVIET MILITARY THOUGHT  
SERIES
- DESIGNED FOR COMMANDERS AND STAFF OFFICERS
- PART 1: MILITARY DECISION MAKING (ORGANIZATION AND INFORMATION FLOW)
- PART 2: FORMAL AIDS TO DECISION MAKING (LANGUAGES, MODELS AND METHODS)
- PART 3: USING COMPUTER TECHNOLOGY (COMPUTATIONS AND DATA RETRIEVAL)



1974

C O N T I N U E D   S O V I E T   P R O G R E S S

- o MAJOR-GENERAL K. V. TARAKANOV AUTHORS MATHEMATICS OF ARMED COMBAT PUBLISHED BY MILITARY PUBLISHING HOUSE
- FOR OFFICERS INTERESTED IN THE QUESTIONS OF AUTOMATION OF MILITARY AFFAIRS
- EMPHASIZES OPTIMIZATION TO USE AT FINAL DECISION MAKING STAGE
- MP APPLICATIONS: NUCLEAR WEAPONS PLANS

1977

R E C E N T   S O V I E T   A C T I V I T Y

- o LT-GENERAL V. REZNICHENKO AUTHORED "THE COMMANDER AND CONTEMPORARY BATTLE:  
THE ART OF CONTROL" IN RED STAR
- IN LAST WAR COMMANDERS AND STAFFS SPENT DAYS AND WEEKS ON OPERATIONS
- THIS MUST NOW LITERALLY BE DONE IN HOURS
- FRUNZE ACADEMY EXPERIMENT USING MATHEMATICAL MODEL OF COMBINED-ARMS COMBAT
- SOME COMMANDERS SOLUTIONS PROPOSED WERE FAR FROM OPTIMAL
- AUTOMATION IN THE HANDS OF COMMANDERS MAKE IT POSSIBLE TO AVOID SUCH  
MISCALCULATIONS

1978

RECENT SOVIET ACTIVITY

o L. G. KHACHIAN PUBLISHES ENTIRELY NEW LINEAR PROGRAMMING APPROACH

- PRESENTED BY A. A. DORODNITSYN IN DOKLADY
- ILLUSTRATES CONTINUED EMPHASIS ON MP
- THEORY: LINEAR PROGRAMMING SOLVED IN POLYNOMIAL TIME
- ALGORITHM: MOVING ELLIPSES INSTEAD OF VERTEX HOPPING  
COMPUTATIONALLY POOR  
CONCEPTUALLY PROMISING

1979

### RECENT SOVIET ACTIVITY

- o CAPTAIN DOCTOR OF NAVAL SCIENCES, V. A. ABCHUK CO-AUTHORED A HANDBOOK OF OPERATIONS RESEARCH
  - FIRST HANDBOOK OF ITS KIND
  - DESIGNED FOR PRACTICAL USE WITH TABLES AND CHARTS
  - REFERENCES ABCHUK (1972), ANUREYEV (1967), CHUYEV (1965), DRUZHININ (1972), SAATY (1963), TARAkanOV (1974), VENTTSEL (1964, 69, 72)
  - LINEAR PROGRAMMING USED IN DISTRIBUTING UNIFORM FORCES ACCORDING TO TARGETS
  - NONLINEAR PROGRAMMING USED WHEN FORCES ARE HETEROGENEOUS
  - DYNAMIC PROGRAMMING USED IN OPTIMUM MOVEMENT AND MULTISTAGE PROBLEMS

SELECTED.  
SPECIALISTS

INFLUENTIAL MILITARY OPERATIONS RESEARCH  
SPECIALISTS USING MP

- o CAPT. V. A. ABCHUK: NAVAL AND GENERAL COMBAT
- o MAJ-GEN. I. I. ANUREYEV: TROOP CONTROL, NUCLEAR WEAPONS AND SPACE
- o MAJ-GEN. YU. V. CHUYEV: WEAPONS DESIGN AND EMPLOYMENT
- o GEN-COL. V. V. DRUZHININ: AUTOMATED TROOP CONTROL
- o MAJ-GEN. K. V. TARAKANOV: SYSTEMS ANALYSIS AND ARMED COMBAT

OTHER INFLUENTIAL AUTHORITIES IN MILITARY  
OR AND MP AREAS

- o A. A. DORODNITSYN: COMPUTERS AND OPTIMIZATION METHODS
- o N. N. MOISEYEV: OPERATIONS RESEARCH AND SIMULATION
- o G. S. POSPLELOV: MODELS AND ARTIFICIAL INTELLIGENCE
- o YE. S. VENTTSEL: COMBAT MODELS AND WEAPONS USE
- o D. B. YUDIN: MODELS WITH UNCERTAINTY



IMPLICATIONS

AND

FUTURE





## I M P L I C A T I O N S

- o IDENTIFY MOST PROMISING MP APPLICATIONS
  - CRITERION
  - VARIABLES
  - CONSTRAINTS
- o IDENTIFY ALGORITHMS AND SOFTWARE
- o EMULATE RESULTS OF MODEL
- o USE RESULTS AS INDICATOR OF INPUTS TO SOVIET DECISIONS

## FUTURE

- o STOCHASTIC PROGRAMMING WILL BE EMPHASIZED TO ADDRESS INCOMPLETE INFORMATION
- o MULTI-CRITERIA OPTIMIZATION WILL BE STRESSED TO REFLECT PRIORITIZED OBJECTIVES
- o ALGORITHMS AND SOFTWARE WILL BE EMPHASIZED
- o MANY MORE SPECIAL AND GENERAL PURPOSE COMPUTERS WILL BE DEPLOYED

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